Elliptic Flow of Unidentified Charged Hadrons at Forward Rapidities in PHENIX

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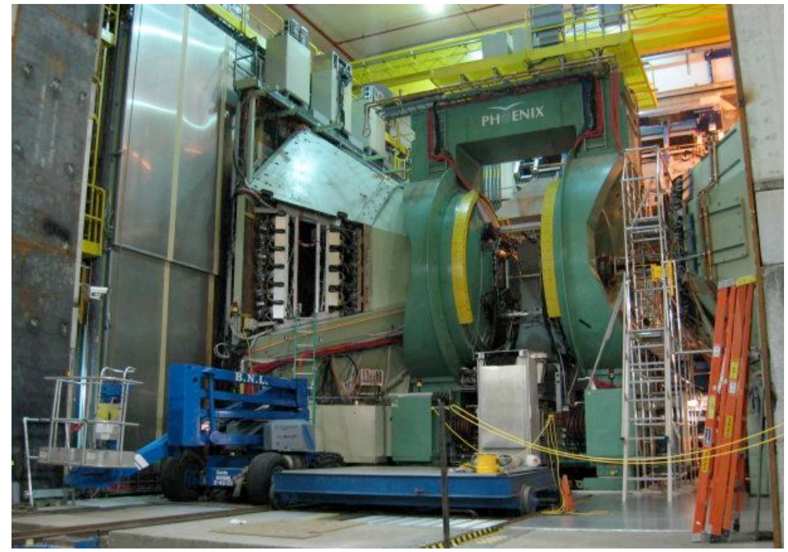
Importance

- Measure hadron elliptic flow (v_2) using PHENIX's forward angle spectrometers called the "Muon Arms."

- The muon arms are unique because they have an η coverage of $|1.2| < \eta < |2.2|$ and are the only detectors at RHIC capable of measuring $v_2(p_T)$ over the entirety of this η region.

- This measurement will help to better understand how v_2 changes with η.



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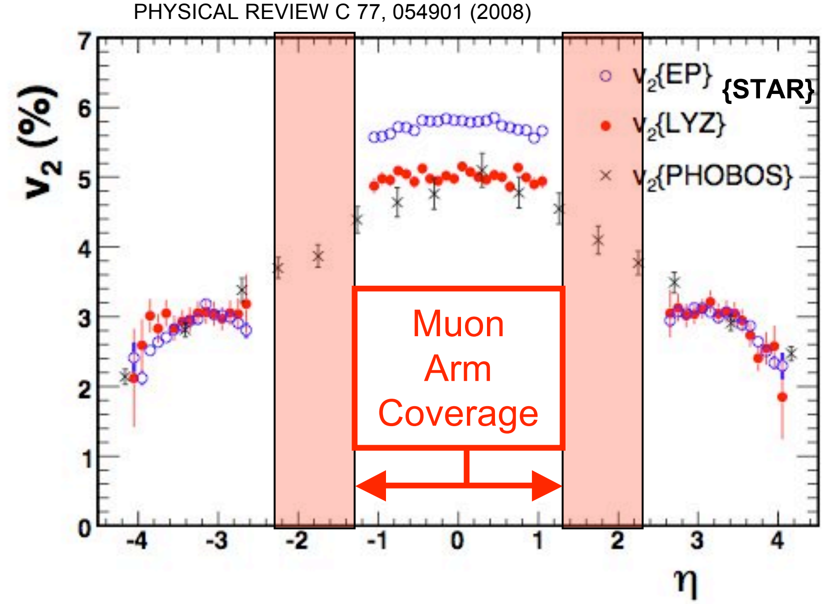
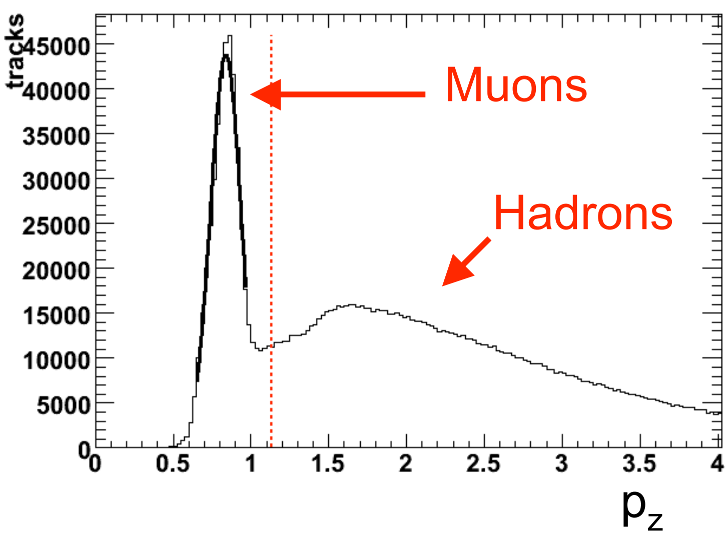
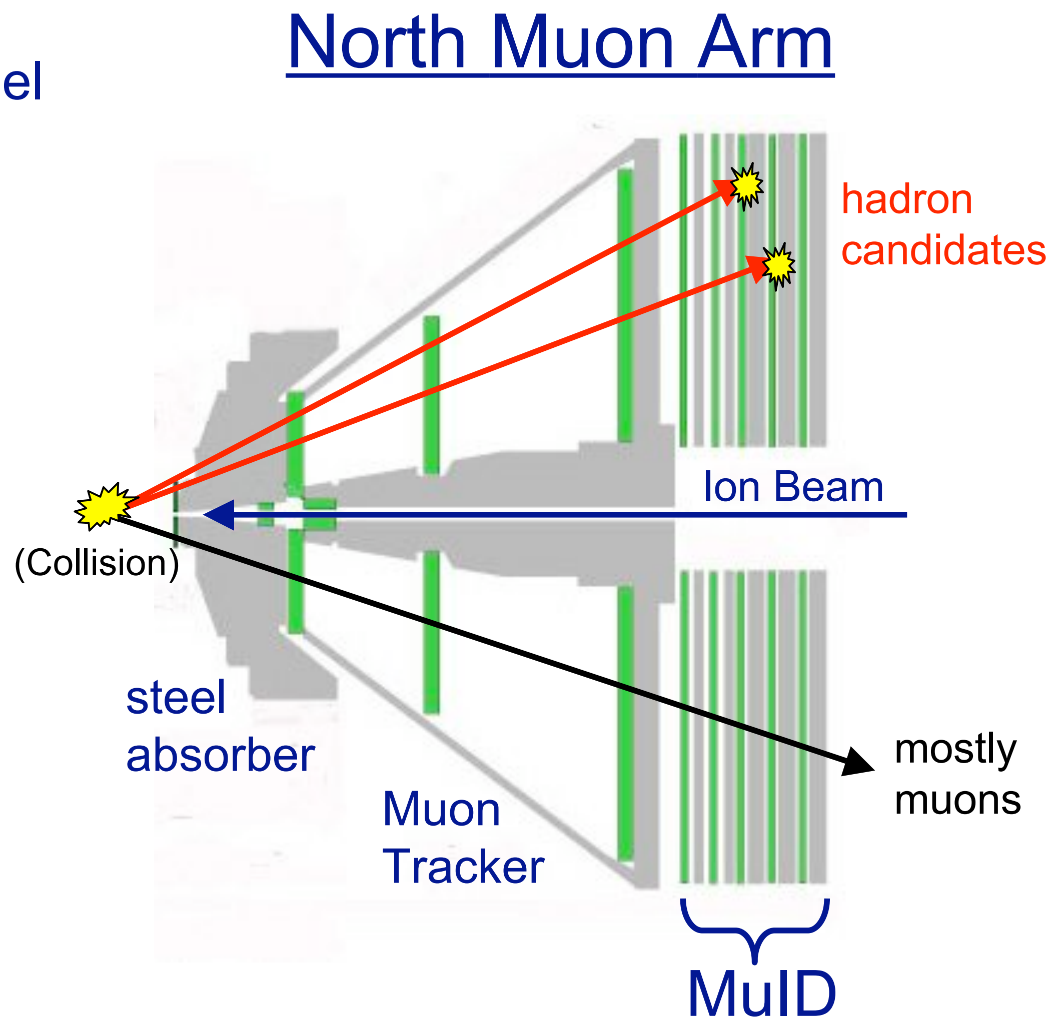


Hadron Identification

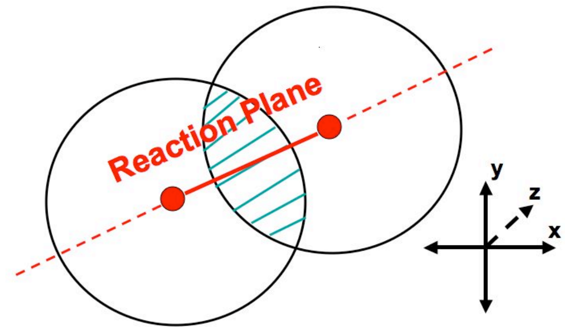
- Use Muon Identifier (MuID)
  - 5 alternating layers of steel absorber and low resolution tracking chambers
- Use only tracks that stop in MuID.
- Plot p_z distribution of stopped tracks.



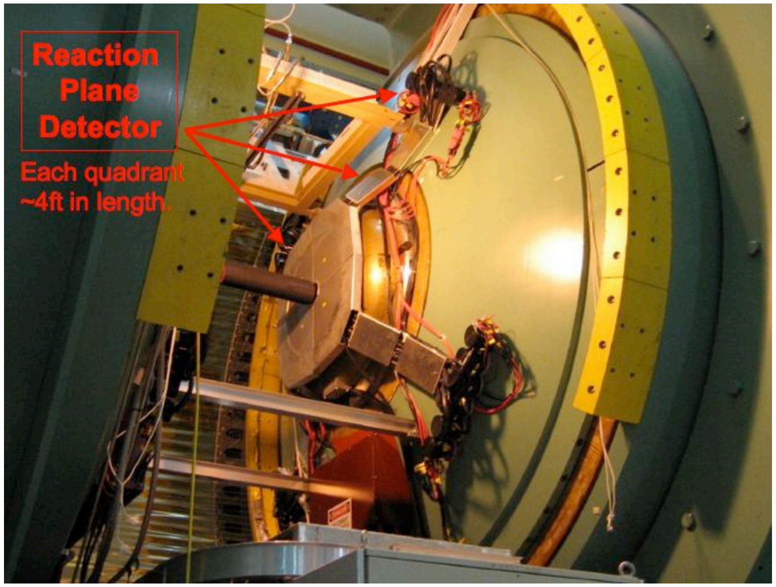


Measuring v_2

- Use standard reaction plane (rp) method which measure particle asymmetry with respect to rp.



- Use rp measured by Reaction Plane Detector (RXNP).
  - 2 halves with each half having 24 plastic scintillators connected to PMT's.
- However, RXNP and muon arms overlap in η coverage.
  - RXNP → $|1.0| < \eta < |2.8|$
  - Muon arms → $|1.2| < \eta < |2.2|$
- To avoid autocorrelations only use the rp from the RXNP half <u>opposite</u> the muon arm the track is traversing.
  - Muon south uses RXNP north rp
  - Muon north uses RXNP south rp

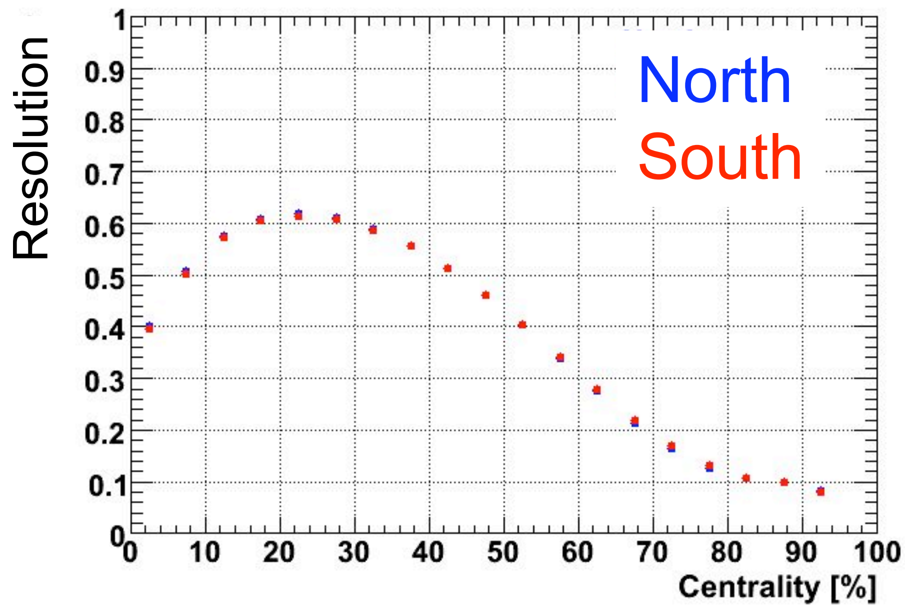


Measuring v_2

- RXNP measures the RP by the asymmetry in the energy deposited into it by the produced particles.

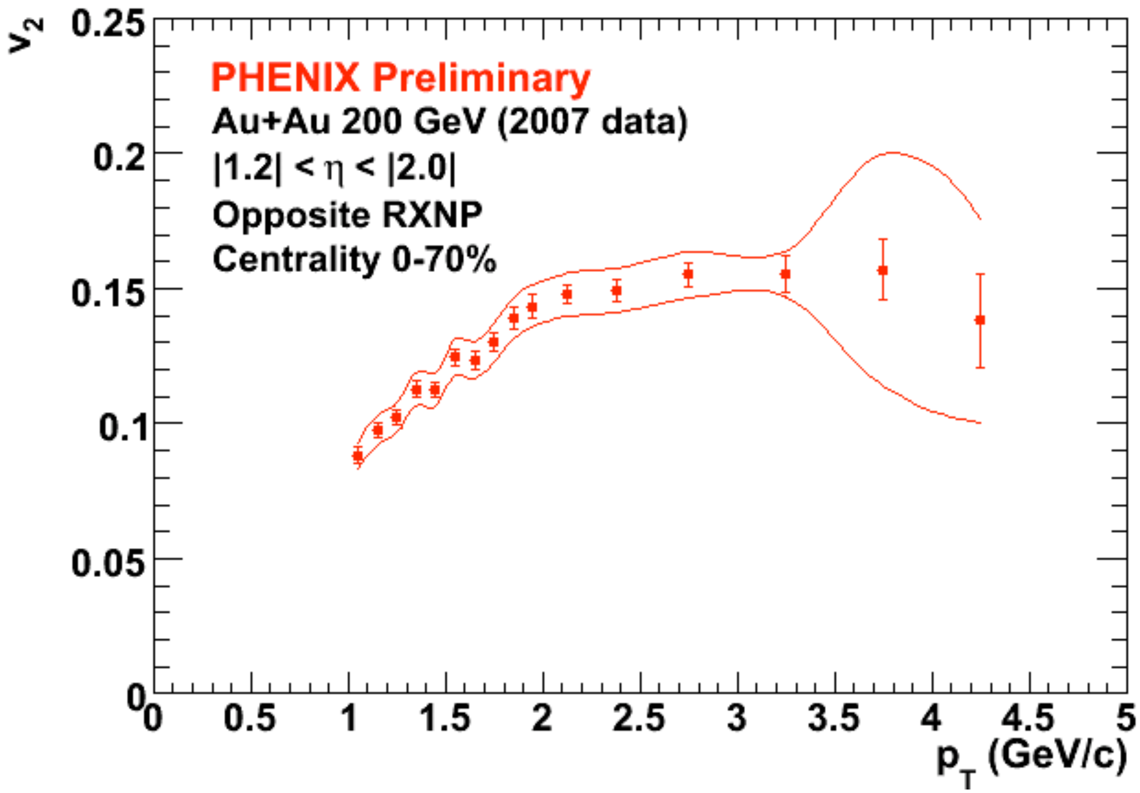
- Calculate raw v_2
  - $v_{2(meas)} = \langle\cos(2(\phi-\Psi))\rangle$
  - ϕ = azimuthal angle of track
  - Ψ = RXNP rp angle

- Correct raw v_2 by RXNP rp resolution (R).
  - $v_2 = v_{2(meas)}/R$



$v_2(p_T)$ at Forward Angles

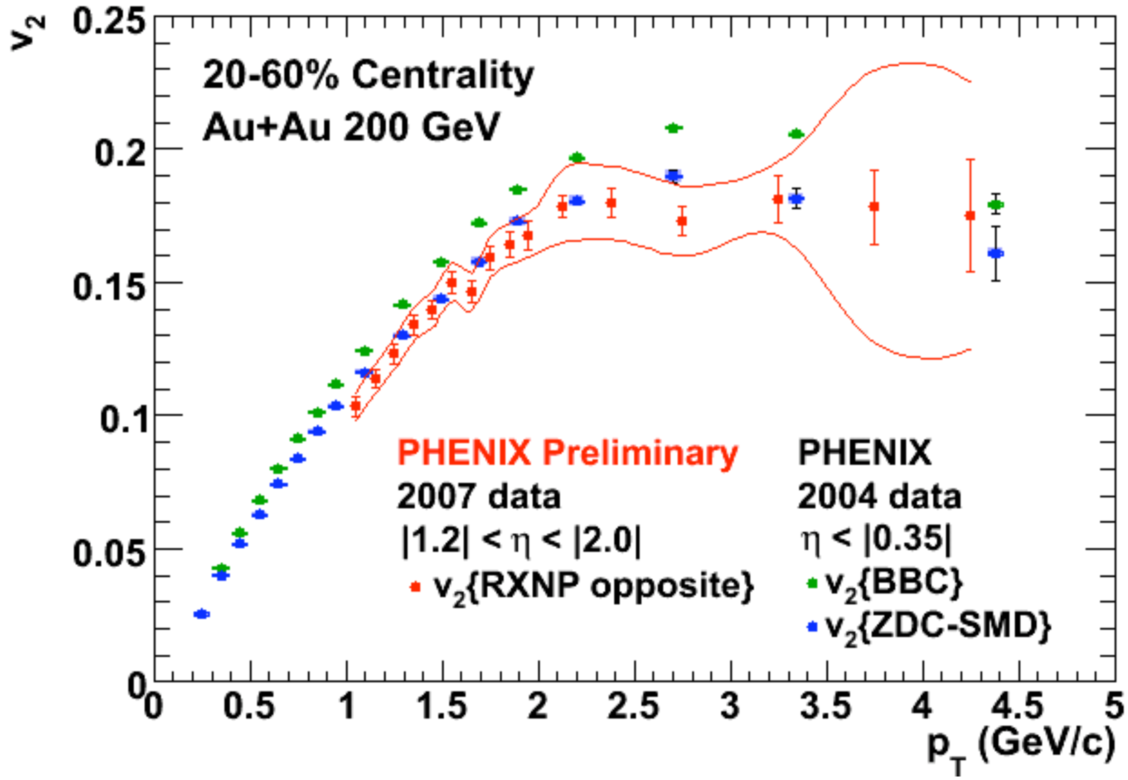
- Bars are statistical errors.
- Lines are systematic errors
  - Reaction plane resolution
  - Background estimation
  - Reaction plane angle used



Comparison to mid-rapidity

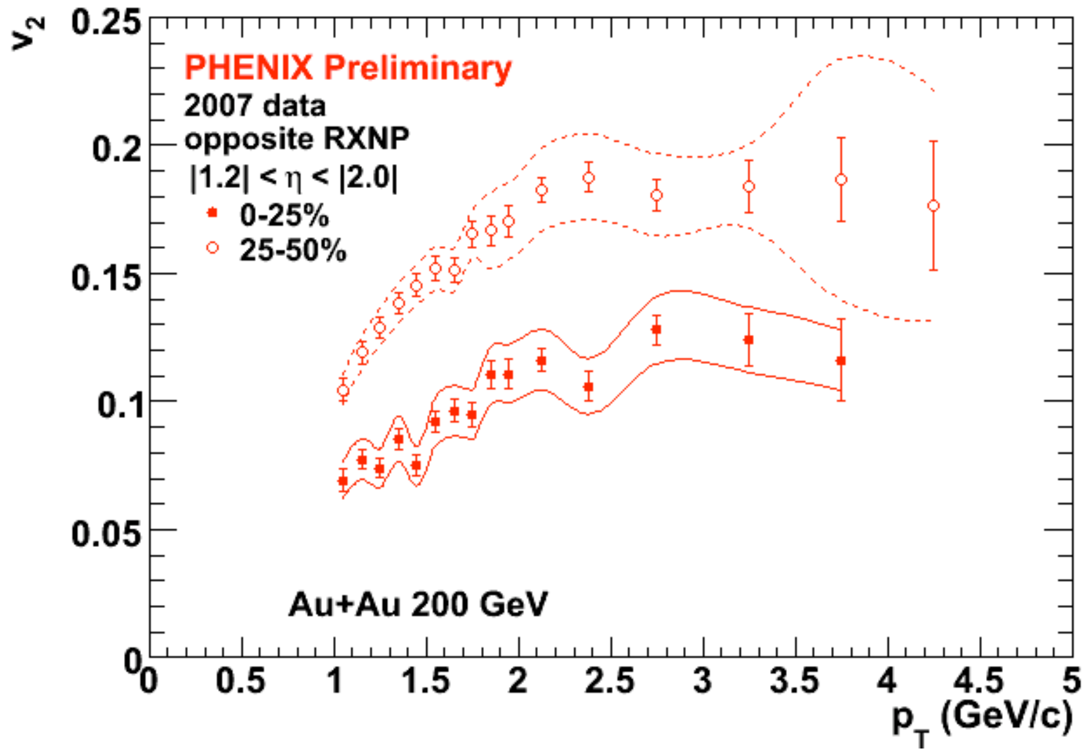
- Mid and forward angle particle composition is not the same so the comparison isn’t exactly apples to apples.
- Also, steel absorber in front of muon arms further alters particle composition.
- However, a comparison is still of interest.

Comparison to mid-rapidity



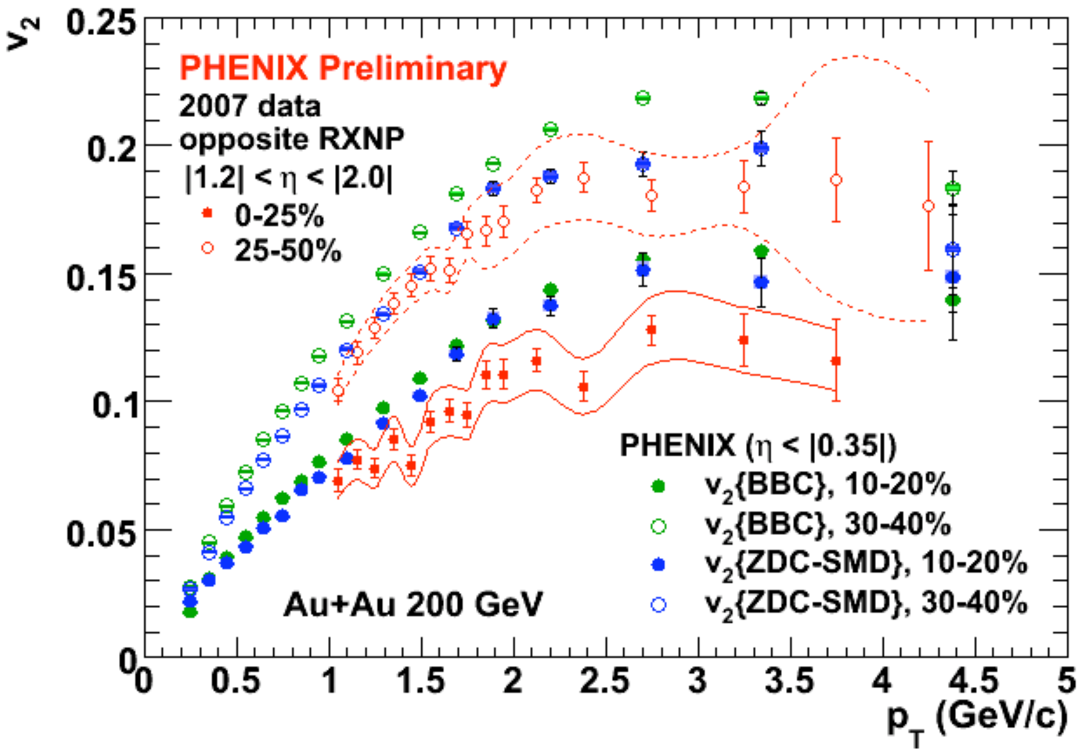
Different η angles yield similar results.

Different Centrality Bins



- Significantly lower signal in central collisions compared to mid-central. A well known behavior.

Centrality bins



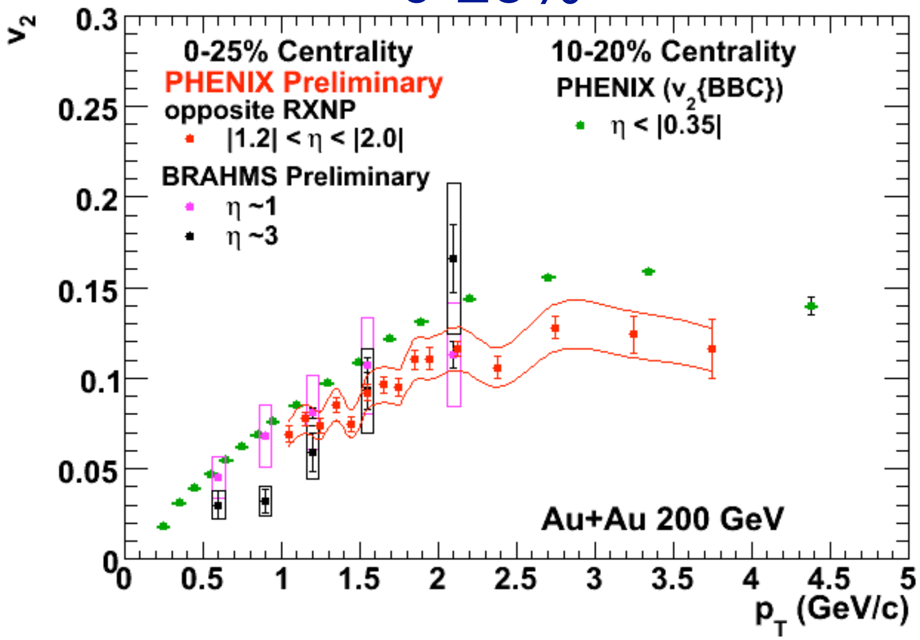
Comparing Cent.	
Forward	Mid
0-25% ⟷	10-20%
25-50% ⟷	30-40%

- Data points indicate a slightly lower signal at forward η but when including errors the signals are similar.
- Of the differences that are seen the larger difference is in the more central bin (0-25%).

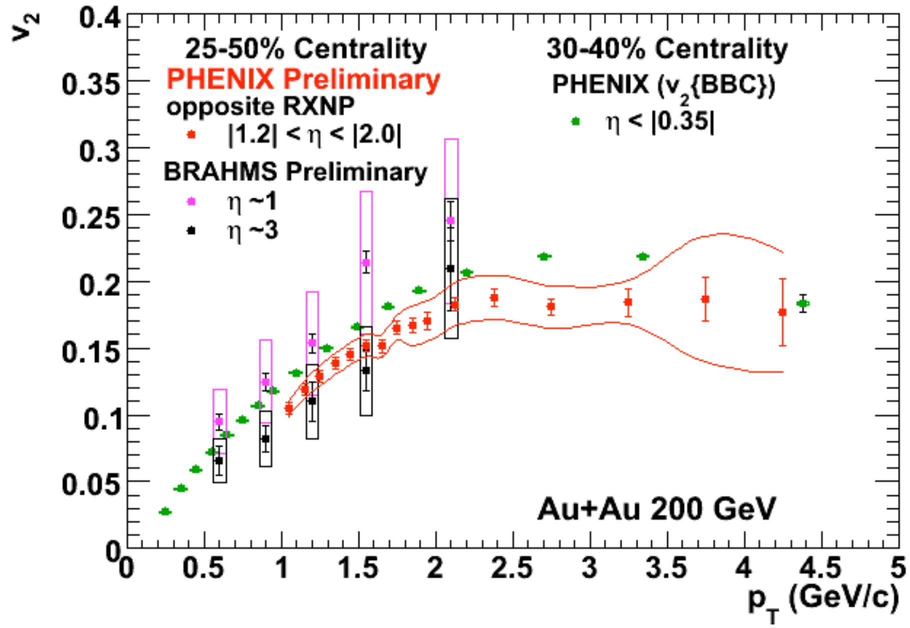
Comparing different η

- Plotting v_2(pT) at 4 different η angles ranging from 0->3.

0-25%



25-50%



- Data points indicate a falling signal with increasing η, but this is not certain when including errors.

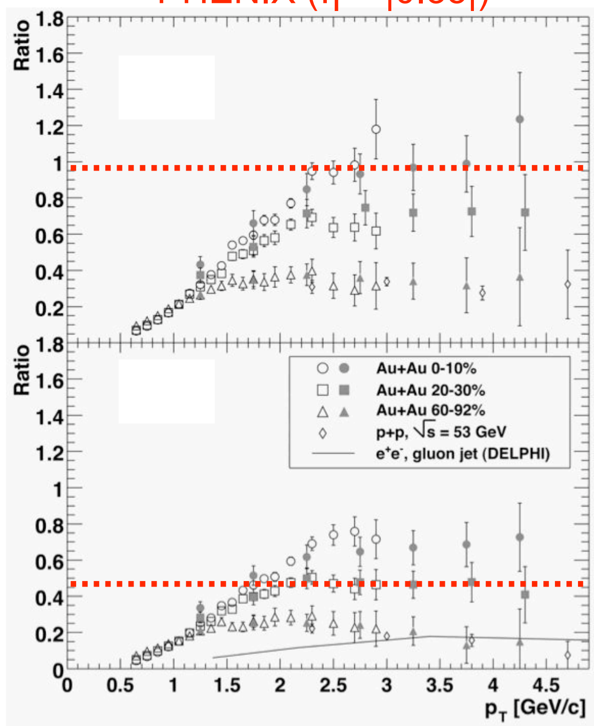
Conclusion

- Strong $v_2(p_T)$ signal seen in the η region of $|1.2| < \eta < |2.0|$.
- Forward and mid-rapidity signals are similar for mid-central collisions (20-60%).
- However, if there is a difference between forward and mid-rapidity measurements it appears with the more central collisions.
- Data points indicate a falling signal with increasing η, but error bars don't make this a certainty.

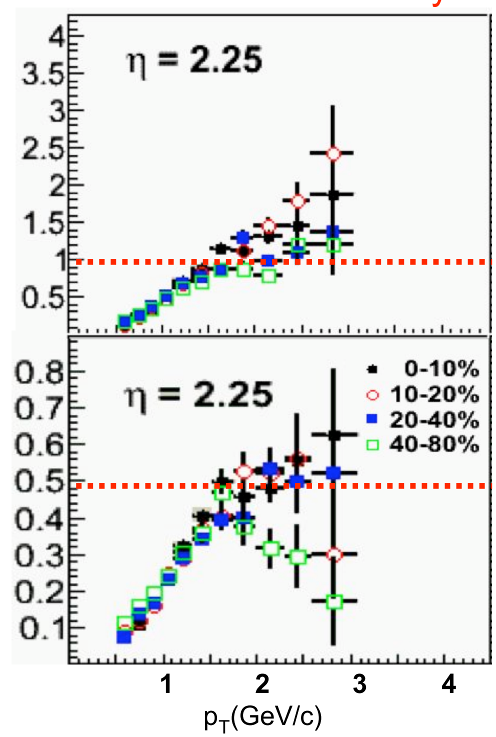
Backup

Particle Composition

PHENIX (η < |0.35|)



BRAHMS Preliminary



p / π^+

$\bar{p} / \pi^-$

- Significant differences seen with p / π^+
- $\bar{p} / \pi^-$ are similar

Reaction Plane Resolution

$$R = \sqrt{\frac{<\cos[2(\Psi^a_{meas} - \Psi^b_{meas})]><\cos[2(\Psi^a_{meas} - \Psi^c_{meas})]>}{<\cos[2(\Psi^b_{meas} - \Psi^c_{meas})]>}}$$

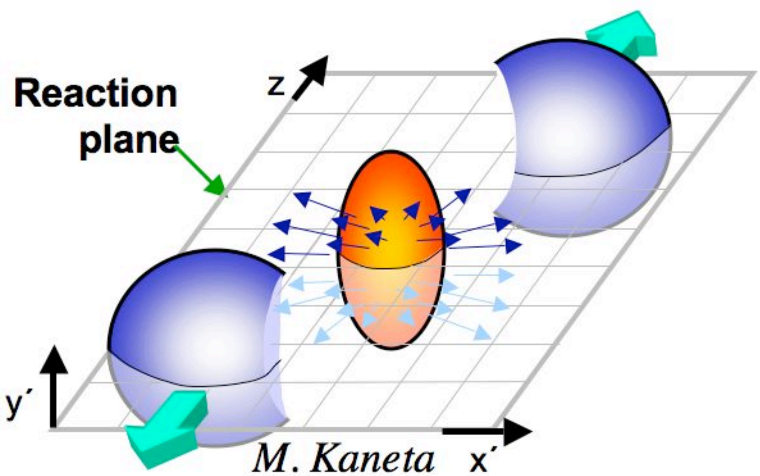
3 sub-events

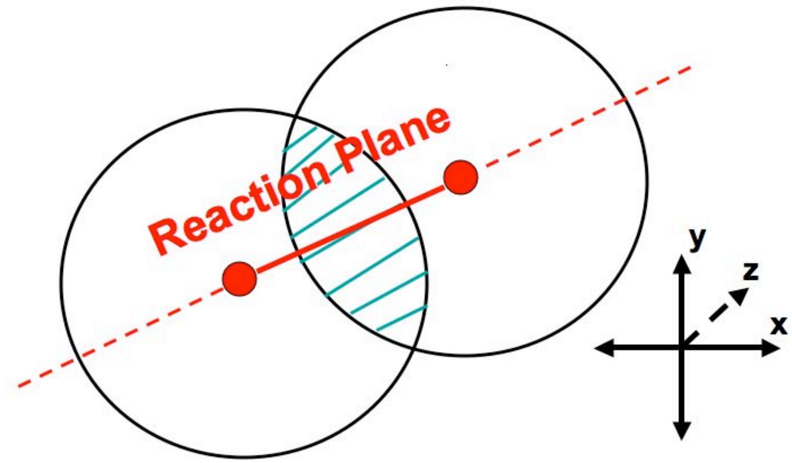
Ψ^a = RXNP_N(S) - opp. side

Ψ^b = RXNP_S(N) - same side

Ψ^c = BBC_NS

What is Elliptic Flow (v_2)?





- Asymmetric distribution of produced particles in the azimuthal direction caused by a spatial anisotropy in the colliding matter
- If matter thermalizes more particles will be emitted in the direction of the reaction plane because of its steeper pressure gradient.